

ANNEX
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
AND COLLABORATIVE COMPOSITES SOLUTIONS CORPORATION
UNDER SPACE ACT UMBRELLA AGREEMENT
NO. 29452, DATED 3/15/2019 (ANNEX NUMBER 2).

ARTICLE 1. PURPOSE

This annex shall be for the purpose of exploring the use of the rapidly changing additive manufacturing technologies for manufacturing heat shields and other spacecraft structures. Currently, the manufacturing of heat shields, and other structures, is labor intensive with no automation, is costly and often the manufacturing techniques constrain the design. Most current heat shields use blocks of material manually bonded to the structure with the gaps between the blocks manually filled by a gap filler. By taking advantage of additive manufacturing technology, automation can be used and it will be possible to build monolithic heat shields with graded materials. This technology would reduce heat shield design and manufacturing complexity and provide a significant reduction in the cost of spacecraft heat shield fabrication. Under a previous annex, selected resin systems for heat shields were evaluated and techniques to print them were developed which demonstrated the feasibility of the technical approach. The current annex builds upon that investigation by expanding the materials and additive techniques to be investigated for heat shields and also expands the investigation into the manufacturing of other spacecraft structures.

NASA needs to be informed of the emerging additive manufacturing technologies that could improve and lower the cost of manufacturing spacecraft heat shields and high-temperature structures. More specifically, NASA is interested in the hardware and techniques used to transport and print highly filled resins especially polymers that are filled with milled and/or chopped carbon, or other, fibers. NASA is also interested in techniques to print materials with imbedded continuous carbon fibers, in-situ part fabrication and part topology optimization.

By participating in this activity, Collaborative Composite Solutions Corporation (“CCSC” or “Partner”) will be able to investigate 3D printing of highly filled thermoset resins that have not previously been printed. The printing of parts from thermoset resins is a rapidly developing technology. Furthermore, with this activity CCSC will gain experience with printing on non-planar surfaces. Typically, parts are 3D printed on planar surfaces. This project builds on the partner’s leadership in 3D printing and extends into new materials and new printing techniques that would have application for structures for high-speed aircraft and spacecraft and potentially for commercial products.

The activities in this agreement are in alignment with the NASA Strategic Plan 2018, Goal 2, “Extend Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.” This agreement also addresses technology gaps identified in the NASA Technology Roadmaps for Entry, Descent and Landing (TA09), Materials, Structures,

Mechanical Systems and Manufacturing (TA12) and Thermal Protection System (TPS) (TA14). This technology will help NASA develop new materials and manufacturing techniques that will make space flight more affordable.

The legal authority for this Annex, consistent with the Umbrella Agreement, is in accordance with the National Aeronautics and Space Act (51 U.S.C. § 20113(e)).

ARTICLE 2. RESPONSIBILITIES

A. NASA JSC will use reasonable efforts to:

1. Assist in organizing Technical Interchange Meetings/telecons (TIMs).
2. Identify spacecraft hardware that would benefit from polymer-based additive manufacturing (AM).
3. Provide detailed descriptions of the manufacturing challenges and requirements for spacecraft structures and components.
4. Share the results of its efforts to 3D print highly filled resin mixtures.

B. Partner will use reasonable efforts to:

1. Setup periodic Technical Interchange Meetings/telecons (TIMs).
2. Provide detailed descriptions of advances in additive manufacturing that may be applicable for spacecraft structures, heat shields and/or other space hardware.
3. Assess the printability of new material systems (identified by the Partner or by NASA) that could be used for spacecraft structures and/or heat shields.
4. Provide detailed descriptions of printer systems that can imbed continuous carbon fibers into the material.
5. Provide recommendations for scaling up printer systems for flight hardware production.
6. Provide educational and training opportunities relevant to technology for novel heat shield and composite manufacturing.

ARTICLE 3. SCHEDULE AND MILESTONES

The planned major milestones for the activities for this Annex defined in the "Responsibilities" Article are as follows:

Partner provides preliminary schedule for TIMs	April 2020
Partner conducts TIM and tour at IACMI facility	July 2020
NASA provides list of space hardware benefiting from AM	Nov. 2020
Partner provides description of advances in AM applicable to space hardware	Feb. 2021
NASA conducts TIM and tour at NASA-JSC facility	May 2021
Partner provides description of printers that imbed carbon fibers	May 2021

NASA provides internal results of 3D printing highly filled resins	May 2021
Partner assesses printability of 1 st batch of new materials	Oct. 2021
NASA provides challenges of space hardware manufacturing	Feb. 2022
Partner provides production scale-up recommendations	June 2022
Partner provides training opportunity at IACMI	Oct. 2022
NASA updates list of space hardware that benefits from AM	Feb. 2023
Partner provides update on AM applicable to space hardware	June 2023
Partner assesses printability of 2 nd batch of new materials	Oct. 2023
Conduct Lessons Learned TIM at IACMI facility	Feb. 2024

ARTICLE 4. FINANCIAL OBLIGATIONS

There will be no transfer of funds between the Parties under this Agreement and each Party will fund its own participation. All activities under or pursuant to this Agreement are subject to the availability of funds, and no provision of this Agreement shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, (31 U.S.C. § 1341).

ARTICLE 5. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. Data produced under this Annex which is subject to paragraph C. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement will be protected for the period of two years.

B. Under paragraph H. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement, Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data provided.

1. Background Data: The Disclosing Party's Background Data, if any, will be identified in a separate technical document.
2. Third Party Proprietary Data: The Disclosing Party's Third Party Proprietary Data, if any, will be identified in a separate technical document.
3. Controlled Government Data: The Disclosing Party's Controlled Government Data, if any, will be identified in a separate technical document.
4. The following software and related Data will be provided to Partner under a separate Software Usage Agreement: None

ARTICLE 6. TERM OF ANNEX

This Annex becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or four years from the Effective Date, whichever comes first, unless such term exceeds the duration of the Umbrella Agreement. The term of this Annex shall not exceed the term of the Umbrella

Agreement. The Annex automatically expires upon the expiration of the Umbrella Agreement.

ARTICLE 7. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Annex by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 8. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Annex.

Management Points of Contact

NASA Lyndon B. Johnson Space Center
Ronald Lewis
Chief, Thermal Design Branch
Mail Stop: ES3
2101 NASA Parkway
Houston, Texas 77058
Phone: 281-483-8863
ronald.k.lewis@nasa.gov

Collaborative Composites Solutions Corporation
Manufacturing Demonstration Facility (MDF)
Cliff Eberle
IACMI, Composites Manufacturing Consultant
2360 Cherahala Blvd
Knoxville, TN 379321563
Phone: 865-661-4292
eberlecc@iacmi.org

Technical Points of Contact

NASA Lyndon B. Johnson Space Center
Stan Bouslog
Thermal Protection Systems TDL
Mail Suite: ES3
2101 NASA Parkway
Houston, Texas 77058
Phone: 281-483-3327
stan.a.bouslog@nasa.gov

Collaborative Composites Solutions Corporation
Manufacturing Demonstration Facility (MDF)
Vlastimil Kunc
ORNL, Team Lead, Polymer Materials Development
2360 Cherahala Blvd
Knoxville, TN 379321563
Phone: 865-946-3104
kuncv@ornl.gov

ARTICLE 9. MODIFICATIONS

Any modification to this Annex shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Modification of an Annex does not modify the terms of the Umbrella Agreement.

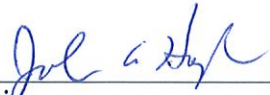
ARTICLE 10. SIGNATORY AUTHORITY

The signatories to this Annex covenant and warrant that they have authority to execute this Annex. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE
CENTER

COLLABORATIVE COMPOSITES
SOLUTIONS CORPORATION
MANUFACTURING
DEMONSTRATION FACILITY (MDF)

BY: _____
Kevin Window
Director, Engineering

BY:  _____
John Hopkins
CCSC CEO

DATE: _____

DATE: March 9, 2020